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The Effect of the Artificial Intelligence Techniques On Humanitarian Logistics Operations in Palestinian Disaster Management Institutions

أثر تقنيات الذكاء الاصطناعي على العمليات اللوجستية الإنسانية في مؤسسات ادارة الكوارث الفلسطينية

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Abstract: Disasters are increasing rapidly in countries around the world. Given the security situation in Palestine, high rates of disaster occurrence are expected in the region in the coming years. Consequently, there exists an urgent necessity to enhance humanitarian logistical operations in Palestine. Artificial intelligence (AI) technologies can greatly improve these activities, according to trends in developing nations. The purpose of this research is to examine how humanitarian logistics operations in Palestinian crisis management organizations are impacted by artificial intelligence approaches. Ninety top and intermediate managers were randomly selected to participate in a survey to gather data. The data was analyzed using partial least squares structural equation modeling (PLS-SEM). The findings indicate that artificial intelligence techniques have a positive impact on the dimensions of humanitarian logistics operations, including speed of response, efficiency, agility, and magnitude of damage mitigation. This study helps practitioners better grasp the opportunities and difficulties of using artificial intelligence techniques in a humanitarian setting in Palestine by providing both theoretical insights and real-world implementations.

Keywords: Artificial intelligence, Humanitarian logistics, Disaster management.

المستخلص: تزداد الكوارث بسرعة في جميع دول العالم. وبالنظر إلى الوضع الأمني في فلسطين، من المتوقع ارتفاع معدلات وقوع الكوارث في المنطقة خلال السنوات القادمة. لذلك، هناك حاجة ملحة لتحسين عمليات اللوجستيات الإنسانية في فلسطين. وبناءً على الاتجاهات في الدول النامية، يمكن لتقنيات الذكاء الاصطناعي أن تسهم بشكل كبير في تعزيز هذه العمليات.

تهدف هذه الدراسة إلى دراسة أثر تقنيات الذكاء الاصطناعي على عمليات اللوجستيات الإنسانية في مؤسسات إدارة الكوارث الفلسطينية. تم جمع البيانات باستخدام استبانة لعينة عشوائية من 90 من المدراء التنفيذيين والمتوسطين. وتم تحليل البيانات باستخدام نموذج المعادلات الهيكلية بالحد الأدنى للمربعات الجزئية.(PLS-SEM)

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تشير النتائج إلى أن لتقنيات الذكاء الاصطناعي أثرًا إيجابيًا على أبعاد عمليات اللوجستيات الإنسانية، بما في ذلك سرعة الاستجابة، والكفاءة، والمرونة، وتقليل حجم الأضرار. تقدم هذه الدراسة رؤى نظرية وتطبيقية، مما يساعد الممارسين على فهم أعمق للتحديات والفرص المرتبطة بتطبيق تقنيات الذكاء الاصطناعي في السياق الإنساني في فلسطين، كما تقدم توصيات للبحوث المستقبلية في الدول النامية.

الكلمات المفتاحية: الذكاء الإصطناعي، اللوجستيات الإنسانية، إدارة الكوارث.

INTRODUCTION

Humanitarian logistics operations, which are known as disaster logistics are among the most difficult processes in this industry. Disaster risk management comprises implementing policies and methods to decrease risks, avoid the introduction of new risks, mitigate existing consequences, and manage residual risks, thereby increasing resilience and lowering disaster-related losses (UNDRR, 2017). Artificial intelligence (AI) refers to a set of tools and procedures that allow computer systems to execute tasks like human intellect. Its purpose is to create models that are capable of learning, reasoning, and making decisions independently. AI spans a wide and ever-changing set of disciplines, drawing on a variety of technologies, techniques, and concepts to create and enhance intelligent systems and applications. These technologies concentrate on how knowledge is represented, processed, and understood to solve difficult issues. (Al Qasim, 2011). AI technologies enable machines to perform tasks that typically require human intelligence such as logical reasoning, learning, and problem-solving—through algorithms and machine learning techniques (Morandín-Ahuerma, 2022). Over time, AI has evolved from a basic concept into a sophisticated system capable of achieving goals through adaptive learning (Haenlein & Kaplan, 2019).

With its vast potential, AI has the capacity to transform both industries and society. Interest in applying AI to emergency and disaster management is steadily increasing as its technologies advance, playing a crucial role in mitigating disaster impacts and saving lives. Specifically, AI can enhance efficiency, effectiveness, and accuracy in disaster preparedness, emergency response, and recovery operations (Sufi & Edris, 2023). Information and data are indispensable for effective disaster response and subsequent recovery planning; however, they are only valuable if processed efficiently and accurately (Offely, 2022). By interacting with human intelligence, AI can support and accelerate decision-making processes particularly critical given that time is often the most challenging factor in combating disasters (Khan, 2022). Nevertheless, despite its significant potential, the successful integration of AI in disaster and emergency management requires addressing multiple challenges and sustaining ongoing research to ensure its effective application and maximize its impact (Dwivedi et al., 2021).

Palestine is classified as a fragile state with medium vulnerability index scores, reflecting its status as a developing country facing political, economic, and social barriers that impede governance, development, sustainability, and disaster risk reduction. Artificial intelligence has been described as "the new oil" for advancing humanity and driving digital transformation (Kittaneh, 2019). Complexity and dispersion are two fundamental characteristics of humanitarian logistics (Wassenhove & Tomasini, 2008). Nevertheless, Palestine's status as an occupied territory complicates logistics operations even further. The country's frail economy, combined with its reliance on international assistance that is greatly influenced by the current political scenario, exacerbates these difficulties, and the government lacks authority over much of its territory (Kittaneh, 2019). In the event of a disaster in Palestine, the circumstance is likely to worsen due to the severe humanitarian circumstances which are more complicated than those found in other developing nations (OCHA, 2017). Consequently, this study aims to assess the effect of artificial intelligence techniques on humanitarian logistics operations, primarily focusing on response time, operational efficiency, agility, and the degree of damage.

1 Literature review and hypothesis Development

Artificial intelligence technology improves humanitarian logistics decision-making by evaluating big datasets to predict demand and optimize resource allocation, allowing for faster and more informed decisions in unpredictable situations (Hussain et al., 2022). Furthermore, AI technologies boost the ability to rapidly uncover alternate solutions by interpreting complicated data, such as satellite images and real-time sensor inputs—to locate new pathways or supply sources during emergencies (Twinanda et al., 2017). Furthermore, AI enables rapid coordination by modeling complex linkages within data, allowing for dynamic alterations to supply chains and logistics activities in response to changing conditions (Ashour, 2020). It also has the ability to automatically manage and coordinate large-scale humanitarian operations, making real-time choices and modifying strategies across different domains without human intervention (Goertzel, 2014). Numan (2024) investigates the critical role of AI in all catastrophe response phases, stressing both the problems of its implementation and ways for overcoming them. In this study, AI showed success in all stages of disaster management, from prediction to recovery, by facilitating rapid decision-making, resource allocation, and humanitarian coordination using cloud-based platforms. Early warning systems, flood prediction, evacuation planning, and satellite image analysis are some of the most important uses. However, demographic considerations continue to influence public perception, underlining the importance of raising awareness and trust while also assuring ethical and transparent AI deployment.

Linardos et al. (2022) investigate new improvements in machine learning approaches to improve catastrophe management strategies. Their results reveal that AI techniques, especially machine learning and deep learning, increase the effectiveness and flexibility of disaster management organizations through boosting detection systems, rapid response, and facilitating making decisions via the analysis of massive amounts of information from multiple sources such as satellites, drones, and social media. These innovations can minimize both human and material losses by boosting prediction accuracy and prioritizing, making them critical instruments for disaster mitigation and organizational capacity building. Atwani et al. (2022) confirm that the majority of widely used AI approaches are very excellent at detecting complicated patterns. Furthermore, Abid et al. (2021) show that AI technologies provide tremendous new skills for recognizing emergencies by sending individuals to a safer location (Laura et al., 2021).

Despite these advances, most previous studies have focused on the application of artificial intelligence in logistics without specifically addressing humanitarian logistics (Chamola et al., 2021). Some studies have examined factors affecting operations without offering solutions for improvement, emphasizing the development of algorithms for specific tasks such as forecasting and guidance. These studies have not fully explored the applicability of AI systems in disaster situations and lack a focus on developing countries.

2.1 Relationship between AI techniques and speed response.

Each incident or disaster requires special considerations, which necessitates that decision-makers quickly assess the situation to ensure the effective distribution of resources. In the context of humanitarian organizations' responses to various types of disasters, time is a critical factor. Additionally, emergency assistance and relief are immediate and direct responses to extreme and unexpected events that lead to acute resource shortages for the population. Humanitarian agencies can utilize machine learning to automate tasks that are typically labor intensive, thereby enhancing the speed of their crisis response. However, in emergency situations, both humans and machine learning models must rapidly adapt to new disasters; they need to adjust in tandem to be effective. Climate conditions, types of construction, and the damage caused by an event may vary from what has been experienced before. Nonetheless, the response must be sharp and attuned to the current situation. Therefore, a model should learn from previous disaster events to recognize the characteristics of damaged buildings, but it must primarily adapt to the environment presented by the new disaster. Damage assessment refers to the initial evaluation of destruction caused by a natural disaster, providing decision-makers with critical insights into the incident's impact. According to Bouchard et al. (2022), damaged buildings serve as strong indicators of the humanitarian consequences of hazards, highlighting areas where people are in urgent need of assistance. Their investigation concentrated on assessing building damage with machine learning and remote sensing imagery. They specifically trained a neural network to automatically locate buildings in satellite pictures and assess damage, illustrating how AI technologies may address the difficulty of insufficient data. Artificial intelligence can assess disaster-related data more precisely and quickly than humans. These methods can also be used on previous disaster data to find patterns and characteristics that influence their occurrence and progression (Amazon Web Services, 2023). As a result, the initial hypothesis of this study is suggested as follows:

H1: Artificial intelligence techniques have a positive effect on the response speed of Palestinian disaster management institutions.

2.2 Relationship between AI techniques and efficiency.

AI technology can improve the effectiveness of disaster management in a variety of ways. Machine learning (ML) and deep learning (DL) approaches may enhance response time throughout disasters by allowing the creation of predictive models that predict crisis progression and appropriate interventions. Neural networks can assess data from a variety of sources to aid in quick and informed decision-making in emergency scenarios. In addition, ML and DL techniques can boost planning and organizational procedures in disaster management by constructing predictive models to better identify and allocate essential resources. Neural networks can also analyze disaster-related data to improve prioritization and direction of efforts (Amazon Web Services, 2023). Accordingly, we propose the second hypothesis:

H2: Artificial intelligence techniques have a positive effect on the operational efficiency of Palestinian disaster management institutions.

2.3 Relationship between AI techniques and agility.

In disaster management, rapid response and agility are critical for effectively addressing disasters and minimizing associated losses. Agility refers to the ability to adapt and make quick, appropriate decisions in response to disasters and changing circumstances. Achieving this requires effective organization and coordinated cooperation among all stakeholders. To enhance rapid response and agility, several measures can be implemented: developing contingency plans that outline specific actions for various types of disasters and clearly define the roles and responsibilities of each team (IDA, 2023); providing ongoing training for disaster management teams to strengthen their capacity to respond efficiently and effectively (UNDRR, 2017); and utilizing advanced technologies and tools to improve disaster monitoring and forecasting, as well as to facilitate communication and coordination among stakeholders (IDA, 2023). Therefore, we propose the following hypothesis:

H3: Artificial intelligence techniques have a positive effect on work Agility in disaster situations

2.4 Relationship between AI techniques and magnitude of damage.

AI technology is rapidly being utilized to forecast predict and recognize natural disasters including floods, earthquakes, and storms. These technologies enable the prediction of potential locations and timing of disaster events (GitHub, 2023). Furthermore, they are employed to analyze images and videos related to disasters. Such analyses allow for the identification of damage and assessment of losses based on post-disaster imagery, thereby facilitating more effective allocation of relief and repair efforts (Laura et al., 2021). Therefore, we propose the fourth hypothesis:

H4: Artificial intelligence techniques have a positive effect on the magnitude of damage resulting from disasters.

This study assumes that artificial intelligence techniques can enhance humanitarian logistics operations, particularly with respect to response speed, operational efficiency, agility, and the reduction of disaster-related damage. Based on the findings of the literature review, the relationships among these variables are illustrated in Figure (1).

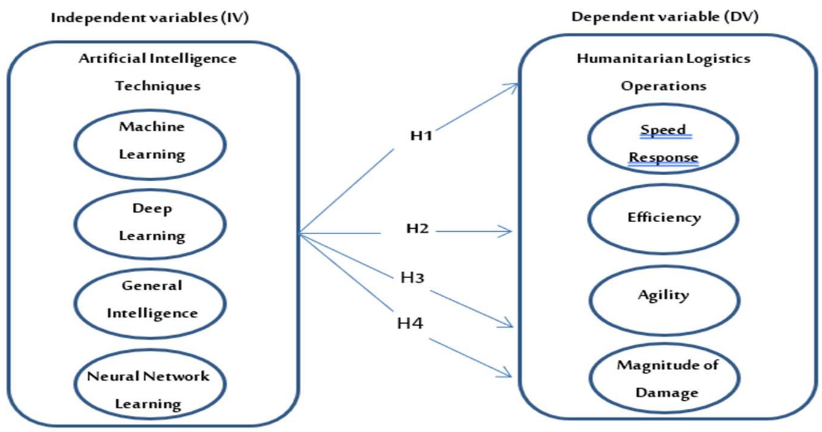

Figure (1): Research Framework

2 METHODOLOGY

This study adopted a quantitative approach, using a survey to collect data from a random sample drawn from several institutions involved in disaster management in Tulkarm city. The city was selected for a cross-sectional study for several reasons. First, despite the presence of other high risk areas, it is considered one of the most dangerous cities in the West Bank. Second, from the beginning of 2023 to the present, the city has experienced numerous adverse events, including killings, destruction, displacement, and continuous incursions by occupation forces. These events have led to an economic situation among the worst in the region, accompanied by a complete lack of security and frequent curfews. Third, the city requires support, which is primarily the responsibility of its residents, and it merits attention to reduce its marginalization. It is important to note that the Gaza Strip was excluded from this study due to the Israeli siege, which prevented researchers from accessing the area to collect data. Consequently, the study was limited to the city of Tulkarm due to the region's ongoing severe security challenges. The targeted respondents were top- and middle-level managers working in disaster management institutions, as they were the primary individuals of interest in this study. They possess a strong understanding of the variables under investigation and are highly knowledgeable about humanitarian logistics concepts within their respective organizations.

The questionnaire consisted of three sections. The first section collected demographic information about the respondents. The second section addressed four main dimensions (i.e., response speed, efficiency, agility, and damage size) through 20 questions adapted from previous studies (Masudin et al., 2021; Khan et al., 2022), with five questions for each dimension. The third section was optional and designed to gather additional comments. Response options ranged from 1 (Strongly Disagree) to 5 (Strongly Agree).

To ensure the questionnaire's validity, it was based on prior global research, underwent a pilot test, and received expert reviews. Additionally, it was translated into Arabic to suit the local context. The questionnaire was distributed to a small group of targeted individuals and experts, who provided feedback on demographic information, clarity, ease of understanding, and relevance of the questions to the research objectives. An online version of the questionnaire was then developed, and the link was sent to the sampled participants.

Out of the 95 questionnaires distributed, five responses were excluded due to incomplete or improper completion. Thus, data from 90 participants (a response rate of 94.7%) were finalized for analysis, a sample size considered adequate based on prior studies. The study targeted institutions that have a direct and significant role in disaster management, selected according to their field of work.

3 RESULTS AND ANALYSIS

3.1 Demographic profiles

The demographic analysis revealed that the majority of respondents hold a bachelor's degree. In terms of work experience, the largest proportion reported having more than 10 years of experience. Furthermore, the results indicated that most participants are employed in government institutions, and the majority are affiliated with local or national organizations, as illustrated in Table (1).

Table (1). Respondent profile

Categories	Categories	Frequency	Percentage
Educational qualification	Diploma	20	22.2
	Bachelor	46	51.1
	Master	21	23.3
	PhD	3	3.3
	Total	90	100.0
Years of working experience	Less than 5 years	23	25.6
	5 - 10 years	28	31.1
	More than 10 years	39	43.3
	Total	90	100.0
Institution Classification	Governmental	62	68.9
	Non- profit institution	13	14.4
	Private	15	16.7
	Total	90	100.0
Scope of the institution’s work	Local/national	71	78.9
	Regional	3	3.3
	International	16	17.8
	Total	90	100.0

3.2 Data Analysis

This study's data analysis was carried out utilizing the PLS-SEM approach, which consists of two major steps. The measurement model tested construct validity and reliability to establish unambiguous distinctions between constructs, whilst the structural model used bootstrapping approaches to uncover significant connections between the variables in the model. This approach was chosen because it is especially appropriate for investigating complex theoretical models, testing direct, indirect, and mediating effects, and its flexible assumptions facilitate the development and validation of intricate models, making it useful for estimating large, complex frameworks (Ramayah et al., 2018). According to Hair et al. (2013), PLS-SEM provides a strong and adaptable framework for researchers to objectively evaluate model configurations and successfully capture causal links between latent constructs. It is chosen over CB-SEM because of its ability to handle complicated models and non-normal data, resulting in more consistent findings.

3.3 Assessment of the measurement Model

The PLS-SEM analysis results show that the measurement model has high reliability and internal consistency. Item loadings above the suggested 0.6 level (see Figure 1). Furthermore, Cronbach's alpha and composite reliability values exceeded the required cutoff of 0.7, and average variance extracted (AVE) values exceeded 0.5, indicating adequate convergent validity (Hair et al., 2019). Table 2 shows detailed results for Cronbach's alpha, composite reliability, and AVE.

Discriminant validity has been established via the Fornell-Larcker criterion. According to this criterion, discriminant validity is proven when the correlation values of the off-diagonal elements between variables are lower than the on-diagonal values (Fornell & Larcker, 1981), as illustrated in Table 3. Furthermore, the Heterotrait-Monotrait ratio (HTMT) was evaluated, which revealed that correlations across variables were less than 0.90 as shown in Table 4. These findings suggest that most constructs have well-established discriminant validity across both approaches (Henseler et al., 2015).

Table (2). Results of the measurement model

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
A	0.784	0.823	0.849	0.534
Al T	0.743	0.747	0.839	0.566
DM	0.843	0.857	0.888	0.615
E	0.831	0.861	0.880	0.596
RS	0.839	0.855	0.885	0.607

Table (3). Fornell and Larcker's Result

	A	Al T	DM	E	RS
A	0.730				
Al T	0.798	0.752			
DM	0.657	0.803	0.784		
E	0.455	0.705	0.466	0.772	
RS	0.583	0.763	0.612	0.465	0.779

Table (4). Heterotrait-monotrait ratio (HTMT)

	A	Al T	DM	E	RS
A					
Al T	0.883				
DM	0.773	0.892			
E	0.512	0.786	0.538		
RS	0.709	0.744	0.419	0.536	

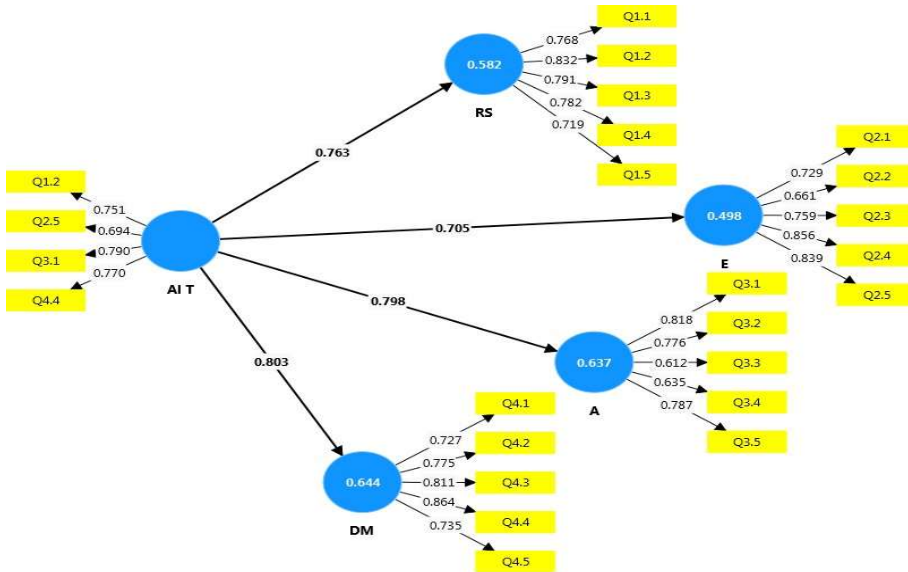

Figure (2). Result of Measurement Model

3.4 Assessment of the Structural Model

The next phase involved analyzing the structural model, including the assessment of path coefficient significance and determination coefficients (R^2) (Hair et al., 2019). According to Chin (1998), R^2 values above 0.67 are considered high, values between 0.33 and 0.67 are moderate, values from 0.19 to 0.33 are weak, and values below 0.19 are unacceptable. Based on the results of this study, all R^2 values meet Chin's (1998) criteria. Table 5 and Figure 2 present the R^2 values for the endogenous latent variables. Furthermore, f^2 was calculated to evaluate the effect size of each predictor. According to Cohen (1988), f^2 values of 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively. In this study, AI technologies demonstrated large effects on Agility (A), Damage Mitigation (DM), Efficiency (E), and Response Speed (RS), with f^2 values of 0.754, 0.811, 0.990, and 0.390, respectively. The predictive relevance of the model was assessed using the Q^2 criterion, with a cutoff value of zero indicating acceptable predictive accuracy (Chin, 2010). The Q^2 values obtained were 0.616 for Agility, 0.628 for Damage Mitigation, 0.478 for Efficiency, and 0.569 for Response Speed, suggesting that the model possesses strong predictive power. Table 5 shows the R^2, f^2, Q^2, and VIF values. The values of the variance inflation factor (VIF) were analyzed to determine whether predictors were multicollinear. VIF values less than 3 suggest no multicollinearity issues, however VIF greater than 5 indicates serious collinearity problems (Hair et al., 2019). In this investigation, all VIF values were less than three, showing the lack of multicollinearity problems.

Table (5). Results of R^2, f^2, Q^2 and VIF

Construct	R^2	f^2 (AI T)	Q^2predict	VIF
A	0.637	0.754	0.616	1.894
DM	0.644	0.811	0.628	2.304
E	0.498	0.990	0.478	1.788
RS	0.582	0.390	0.569	1.383

Utilizing the PLS technique and bootstrapping, the analysis evaluated the proposed hypotheses by looking at the significance of path coefficients and their alignment with the hypothesized directions. Table 6 and Figure 3 show the empirical findings of the bootstrapping process, including β values, standard deviations, t-values, and p-values for both direct and indirect correlations, acquired from 5,000 subsamples. The findings indicate a significant positive relationship between AI technologies and response speed, efficiency, agility, and damage mitigation, thereby supporting the proposed hypotheses: H1 ($\beta = 0.763$, $t = 16.748$, $p < 0.001$), H2 ($\beta = 0.705$, $t = 12.153$, $p < 0.001$), H3 ($\beta = 0.798$, $t = 25.610$, $p < 0.001$), and H4 ($\beta = 0.803$, $t = 28.796$, $p < 0.001$).

Table (6). Hypothesis testing

Hypothesis		Beta (β)	Std. Dev.	t-value	p-value	Decision
H1	AI T -> RS	0.763	0.046	16.748	0.000	Supported
H2	AI T -> E	0.705	0.058	12.153	0.000	Supported
H3	AI T -> A	0.798	0.031	25.610	0.000	Supported
H4	AI T -> DM	0.803	0.028	28.796	0.000	Supported

Note: AI T = Artificial intelligence techniques, RS = Response speed, E= Efficiency, A= Agility, MD = Magnitude of Damage.

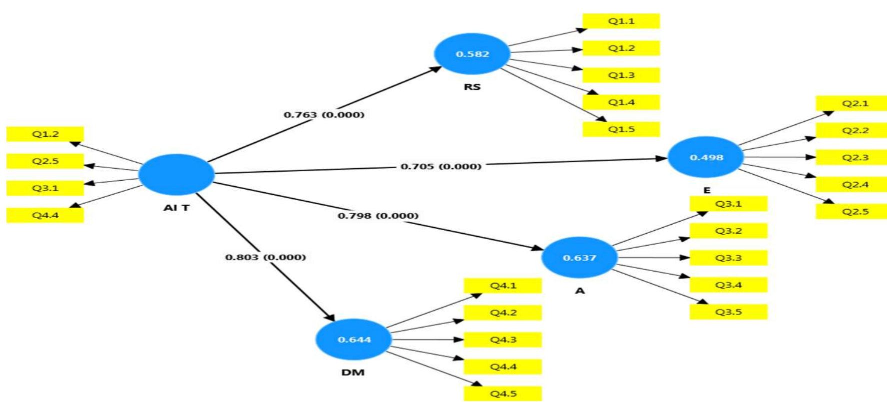

Figure (3). PLS Bootstrapping

4 DISCUSSION AND CONCLUSION

4.1 Discussion

The current study's findings are broadly compatible with earlier studies showing the beneficial effects of AI technologies in humanitarian logistics. This study, similar the research of Choi et al. (2023) and Linardos et al. (2022), emphasizes the significance of artificial intelligence in enhancing the speed and accuracy of emergency response via enhanced data processing and prediction methodologies. The current study focuses on AI technologies, which have helped to improve organizational effectiveness, resilience, and reduce the extent of catastrophic damage.

Nguyen et al. (2023) and Laura et al. (2021) highlight AI's role in the best decision-making and planning, that supports the current study's findings of increased organizational efficiency and resilience. Furthermore, studies such as Atwani et al. (2022) and Rigter (2022) show that hybrid AI approaches and sequential decision-making models improve organizational flexibility under uncertain settings, which is consistent with our findings. In a similar vein, Abid et al. (2021), Bent (2021), Ben et al. (2020), Chamola et al. (2021), and Numan (2024) show that AI applications, including systems for early warning, modeling for prediction, evacuation planning, and real-time data analysis, reduce human and material losses during disasters, confirming the current study's positive findings. Kittaneh (2019) identified key parameters influencing the efficacy of humanitarian logistics operations in the West Bank, Palestine. Prior research recognized operational issues and weaknesses but did not offer meaningful methods to solve them. Conversely, this research goes one step further by investigating the use of AI technology as a solution to increase logistics efficiency, quickness, and agility. Respondents, including engineers from the Engineers' Association and civil defense personnel, emphasized that AI saves time and effort while emphasizing the significance of adequate preparation and training for critical disaster scenarios involving communication and AI systems.

Overall, the study demonstrates that the extent of damage decreases as organizational response, efficiency, and flexibility improve, supporting previous literature, such as Wassenhove and Tomasini (2009), which indicates a relationship between improved logistics and reduced disaster impact. The study treats damage as a dependent variable and AI techniques as a constant factor, with data collected from respondents confirming the positive impact of AI techniques on reducing damages. By presenting a practical model for applying these techniques, this research provides a strong basis for enhancing humanitarian logistics in Palestine and emphasizes the importance of involving the local community to ensure sustainability. These contributions also justify the novelty of the study, as it is the first of its kind in the Palestinian context to empirically examine AI techniques impact in transforming humanitarian logistics operations.

4.2 Conclusion

In conclusion Many powerful countries have resorted to using artificial intelligence in humanitarian logistics. Artificial intelligence simulates human intelligence and enhances human capabilities and skills, which is a positive indicator for improving humanitarian logistics since it heavily relies on diverse human capacities and skills. This necessitates logical reasoning, knowledge, strategic planning, and virtual perception. Moreover, it can perform many tasks through its techniques, which appear to us in the form of complete systems, such as the ability to learn automatically, make accurate decisions based on analysis and information acquisition through practical practices, and respond quickly to variables and much more. Artificial intelligence alleviates the burden on humans and handles dangerous tasks such as exploration work and risky rescue operations during disasters and arduous work. Based on all the above, the researcher decided to conduct this research , The results show that the use of AI technologies include : machine learning, deep learning, general intelligence and artificial neural network learning improves human logistics operations and thus affects the speed of response, efficiency, agility and the size of damage .the research results were positive and support the hypotheses, therefore the effect of their use is very wide and this research shows a specific part of the impact. This study has several limitations that may affect its findings. First, the use of a cross-sectional survey provides only a snapshot of the relationships among the constructs, limiting the ability to infer causal effects over time. Future research should consider adopting a longitudinal design to gain a more comprehensive understanding of AI's role in enhancing humanitarian logistics operations. Additionally, incorporating qualitative methods, such as interviews with managers and practitioners, could provide deeper insights into the factors influencing the successful adoption and implementation of AI technologies in the humanitarian sector.

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